Fertilizer Value of Nitrogen in Irrigation Water for Coastal Vegetable Production

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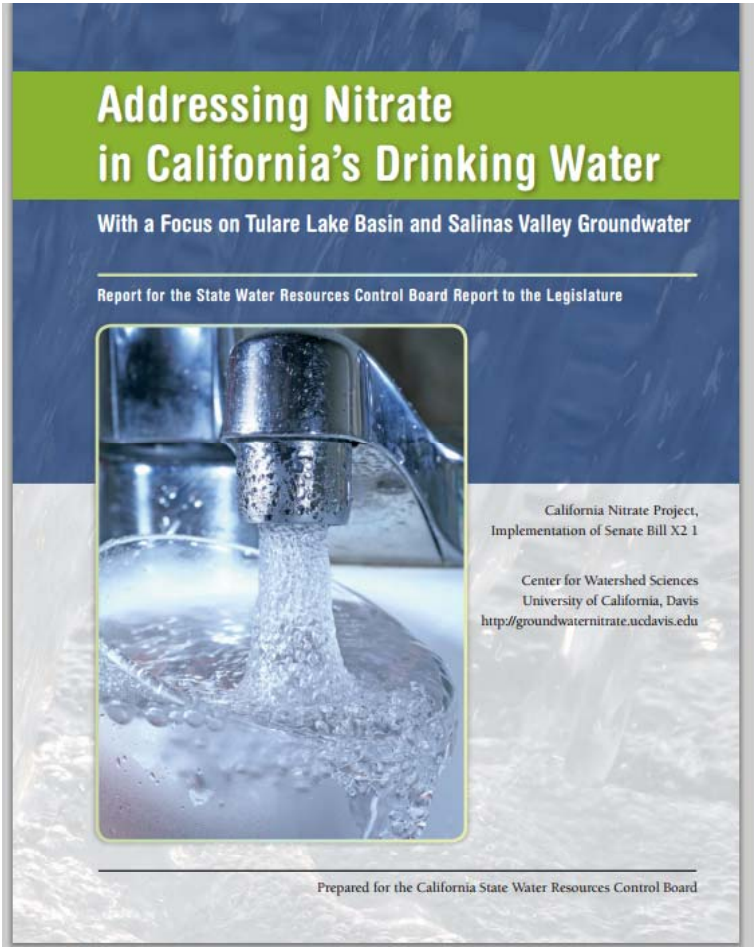
SWRCB SBX2 1

“Pump and fertilize” was proposed as a partial solution for remediating nitrate contamination of ground water



Harter and Lund 2012

How much fertilizer credit should be taken for nitrogen in well water?

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- Does the volume of applied water affect N recovery?
- Is there a minimum concentration of nitrate in water that has fertilizer value?
- Does the form of N (nitrate vs ammonium) affect recovery?

Replicated Trials

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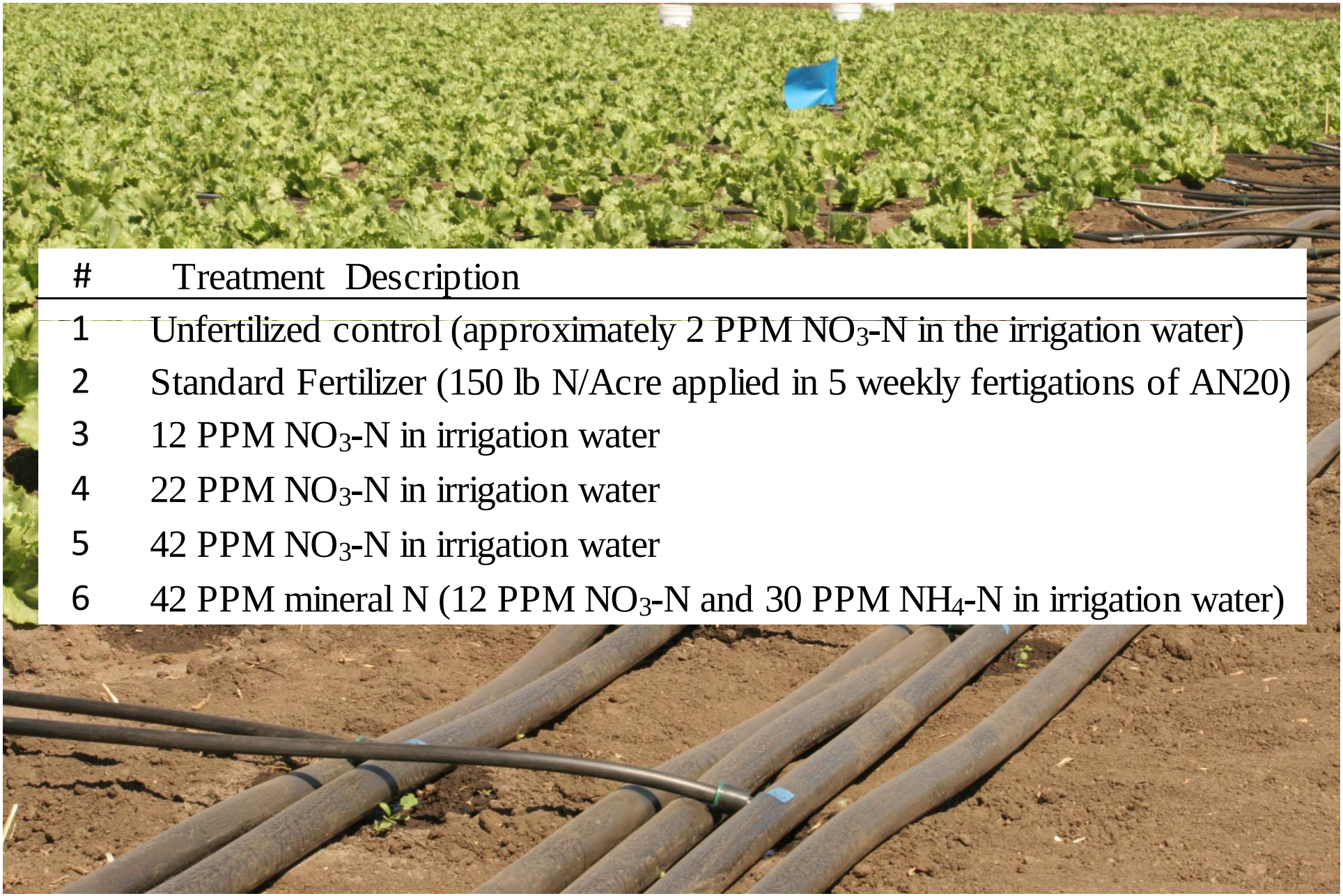
- USDA-ARS Spence Research Farm
- Chualar sandy loam soil
- Well water (2 to 3 ppm NO_3-N)
- Iceberg lettuce (*cv.* Telluride), broccoli (*cv.* Patron)
- 2 lettuce trials: summer and fall harvests; 1 broccoli trial: fall harvest
- N at planting (anti-crustant)
- Plots = 45 ft x 4 beds (40 inch width)

Water N treatments were applied by drip



#	Treatment Description
1	Unfertilized control (approximately 2 PPM NO_3-N in the irrigation water)
2	Standard Fertilizer (150 lb N/Acre applied in 5 weekly fertigations of AN20)
3	12 PPM NO_3-N in irrigation water
4	22 PPM NO_3-N in irrigation water
5	42 PPM NO_3-N in irrigation water
6	42 PPM mineral N (12 PPM NO_3-N and 30 PPM NH_4-N in irrigation water)

Irrigation Manifold for Simulating Water with Varying Concentrations of Nitrate

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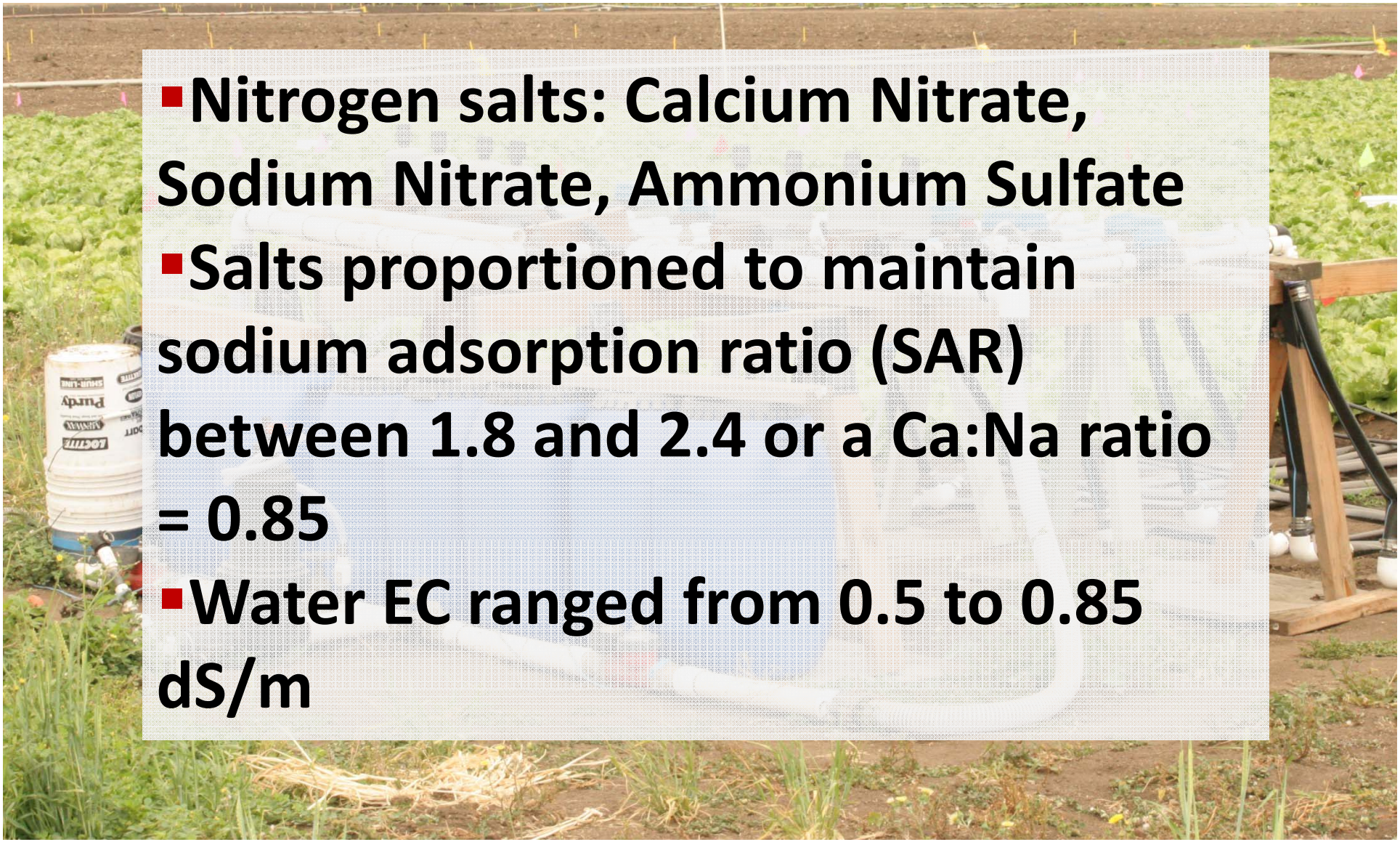

- Nitrogen salts: Calcium Nitrate, Sodium Nitrate, Ammonium Sulfate
- Salts proportioned to maintain sodium adsorption ratio (SAR) between 1.8 and 2.4 or a Ca:Na ratio = 0.85
- Water EC ranged from 0.5 to 0.85 dS/m

Two irrigation rates were evaluated

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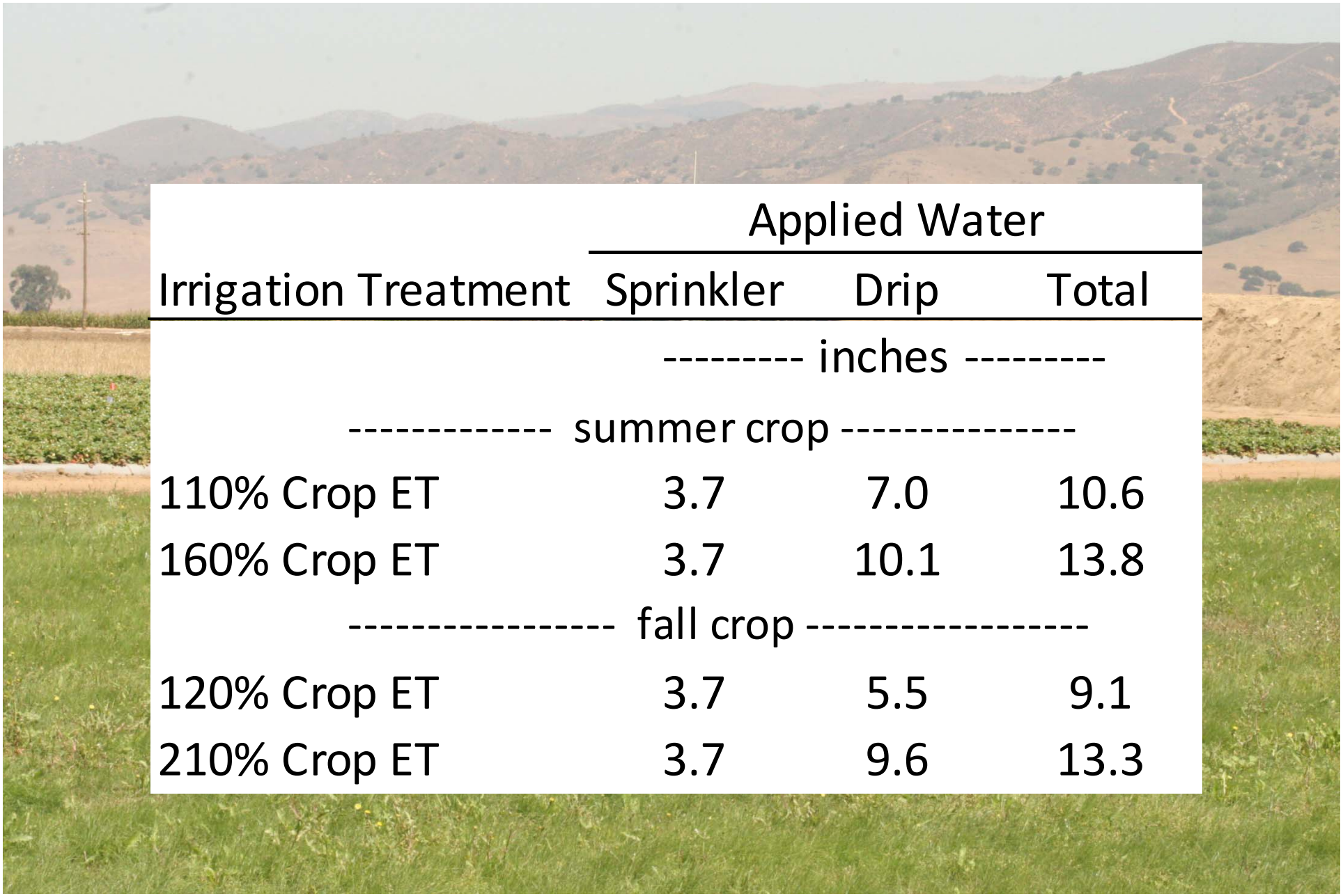

Irrigation Treatment	Applied Water		
	Sprinkler	Drip	Total
	--------- inches ---------		
---------- summer crop ----------			
110% Crop ET	3.7	7.0	10.6
160% Crop ET	3.7	10.1	13.8
---------- fall crop ----------			
120% Crop ET	3.7	5.5	9.1
210% Crop ET	3.7	9.6	13.3

How is nitrate in irrigation water converted to applied N?

lbs of N/acre=

applied water (inches) x NO_3-N conc (ppm) x 0.23

		Fertilizer N value	
	Applied	NO_3-N	
ET Treatment	Water	12 ppm	22 ppm
	inches	------ lbs N/acre ----	
110%	7.0	19.3	35.4
160%	10.1	27.9	51.1

Verifying N concentration of irrigation water treatments

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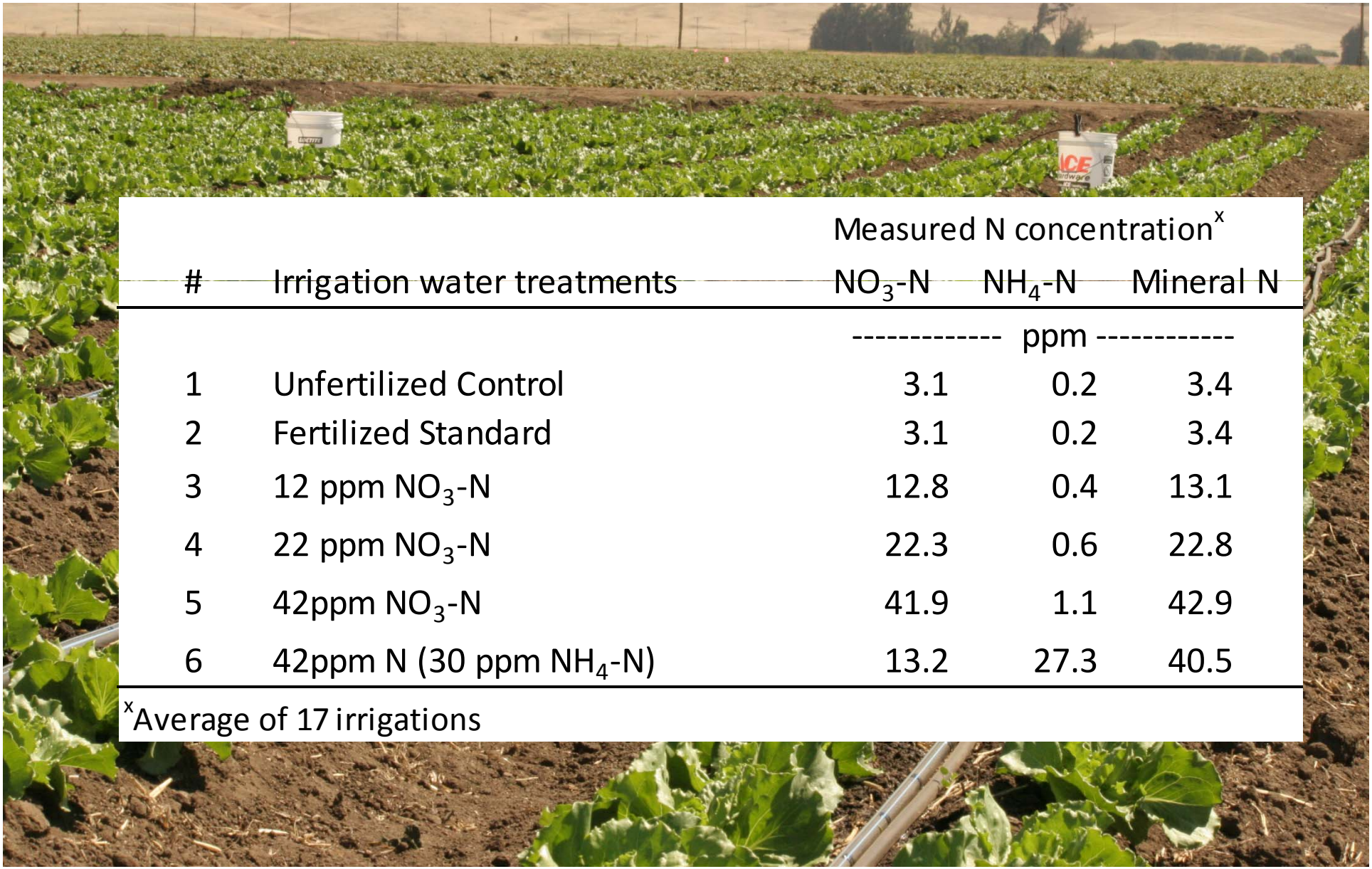


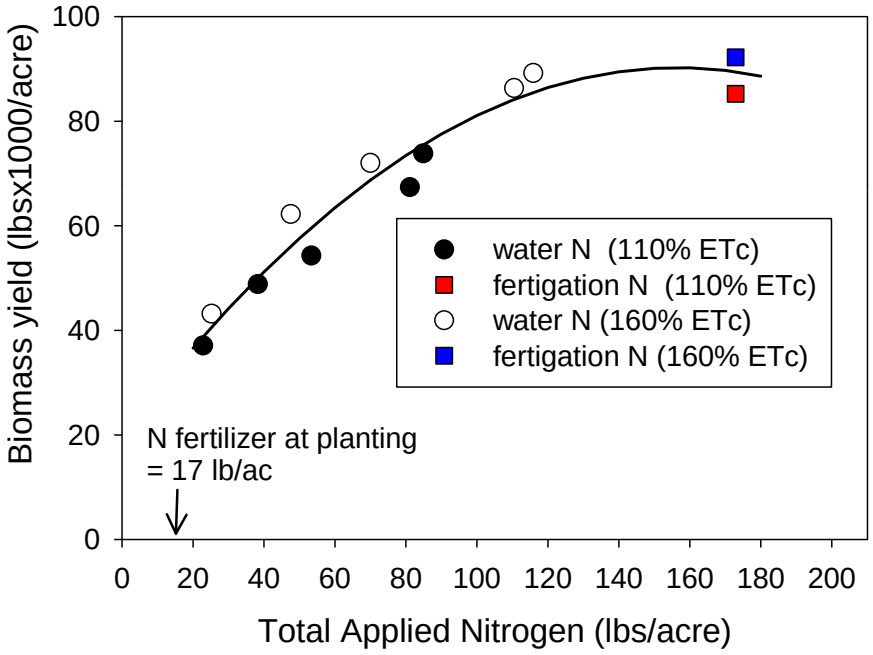
#	Irrigation water treatments	Measured N concentration[x]		
		NO_3-N	NH_4-N	Mineral N
		---------- ppm ----------		
1	Unfertilized Control	3.1	0.2	3.4
2	Fertilized Standard	3.1	0.2	3.4
3	12 ppm NO_3-N	12.8	0.4	13.1
4	22 ppm NO_3-N	22.3	0.6	22.8
5	42ppm NO_3-N	41.9	1.1	42.9
6	42ppm N (30 ppm NH_4-N)	13.2	27.3	40.5

[x]Average of 17 irrigations

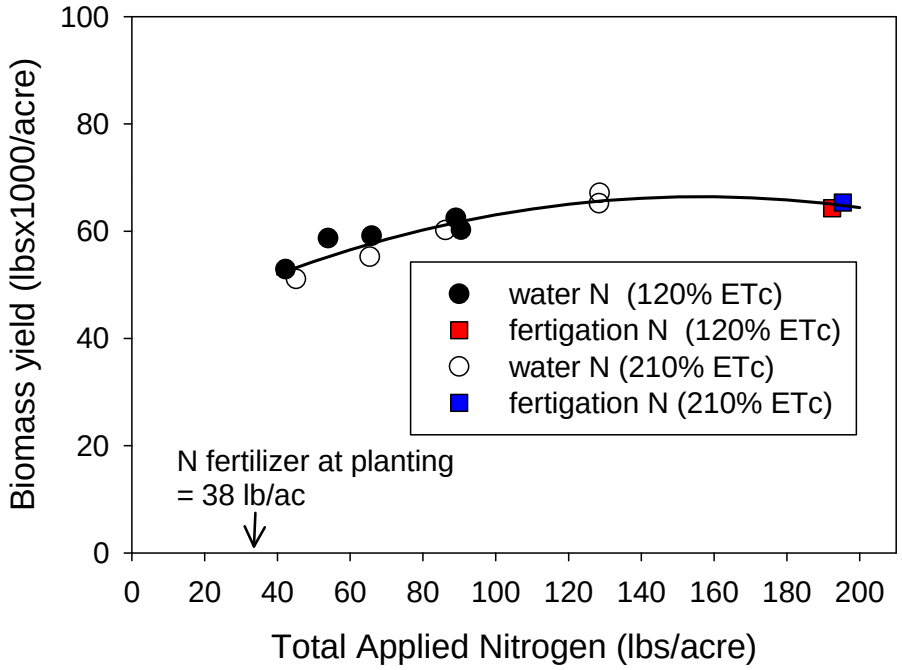
Nitrogen in water affected both plant size and color

Irrigation Water Treatments Affected Biomass Yield

Summer

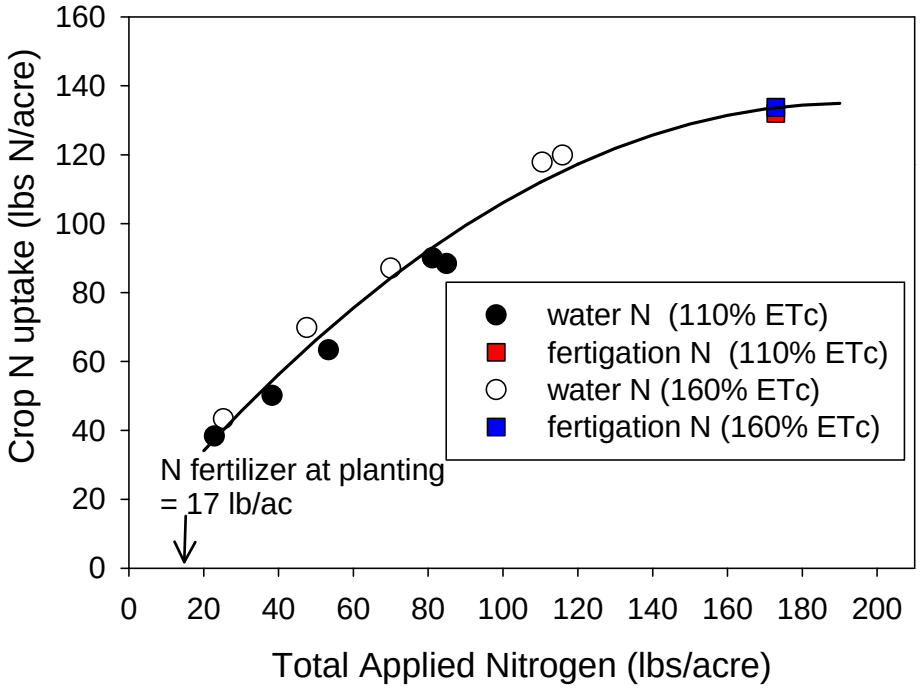


Fall

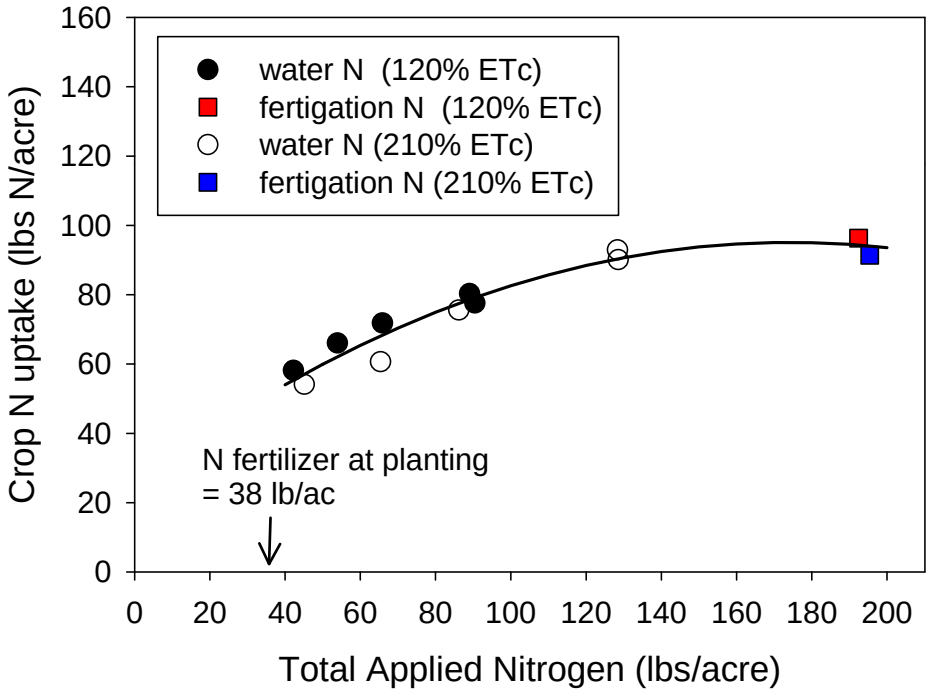


Irrigation Water Treatments Affected Crop Uptake of Nitrogen

Summer

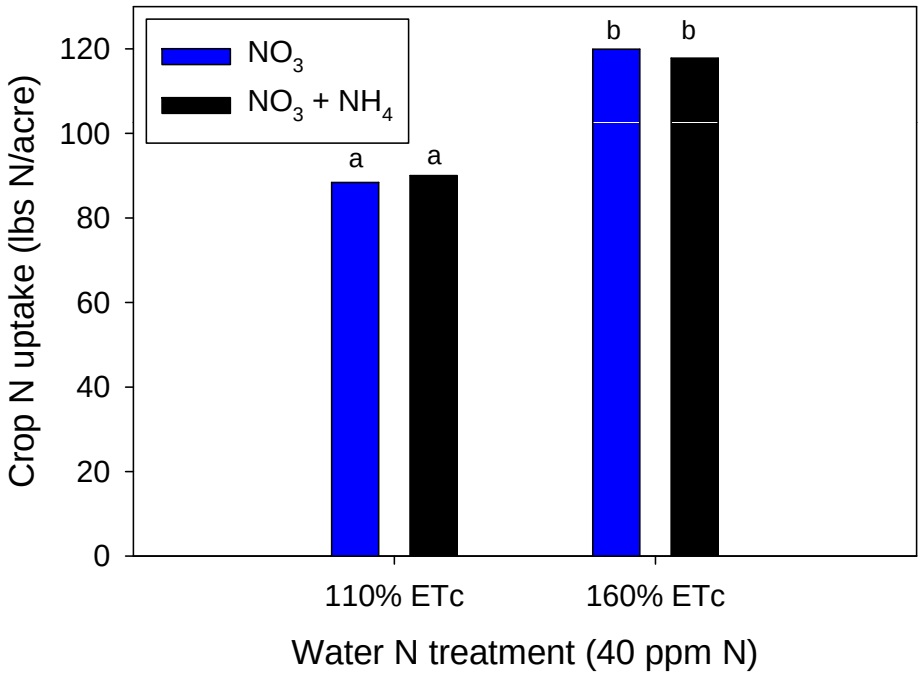


Fall

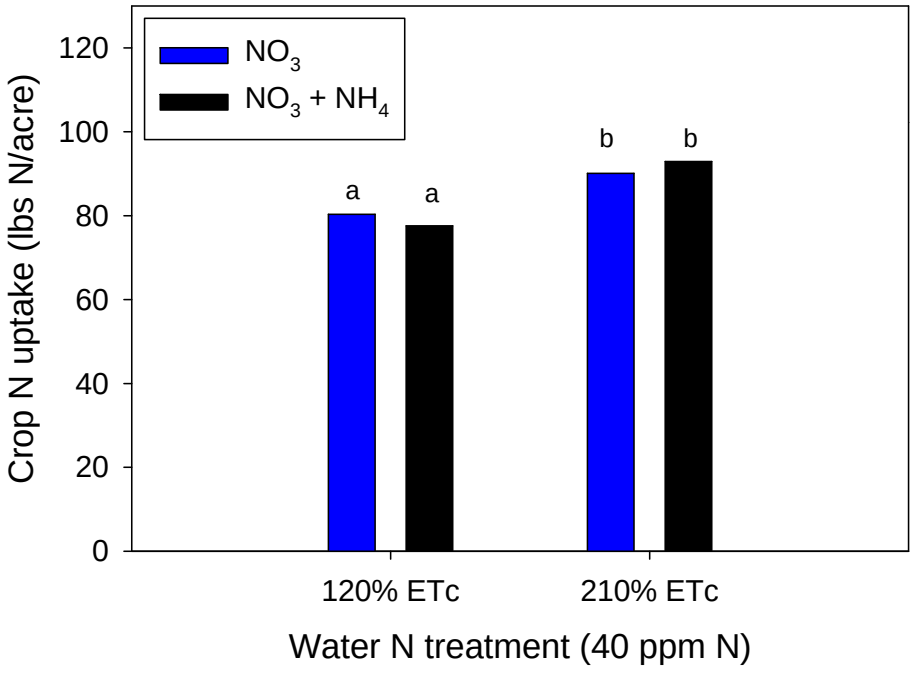


Crop uptake of N was similar for NH_4 and NO_3 sources in irrigation water

Summer

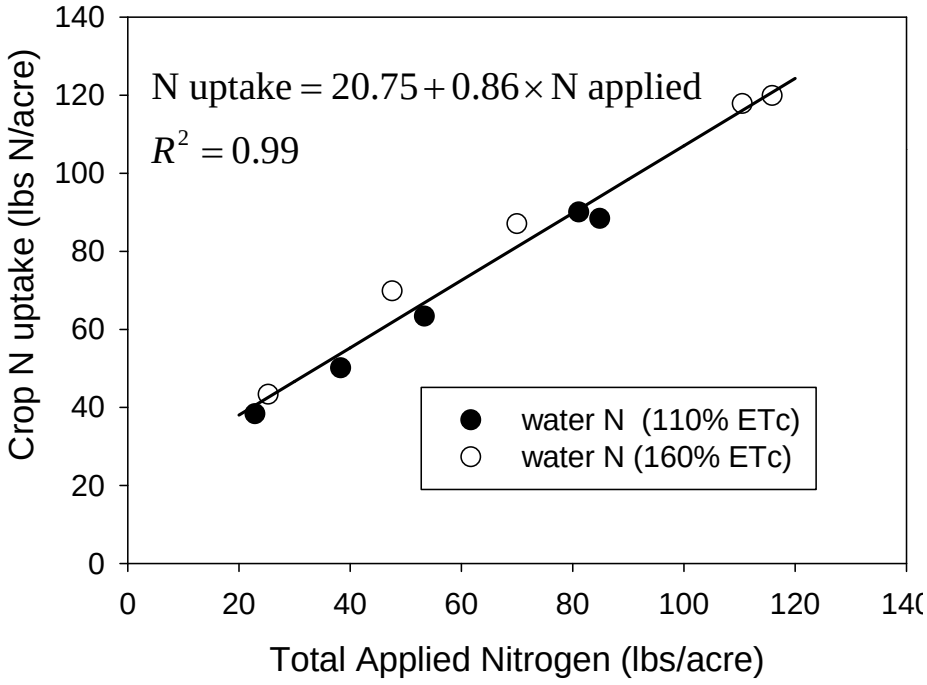


Fall

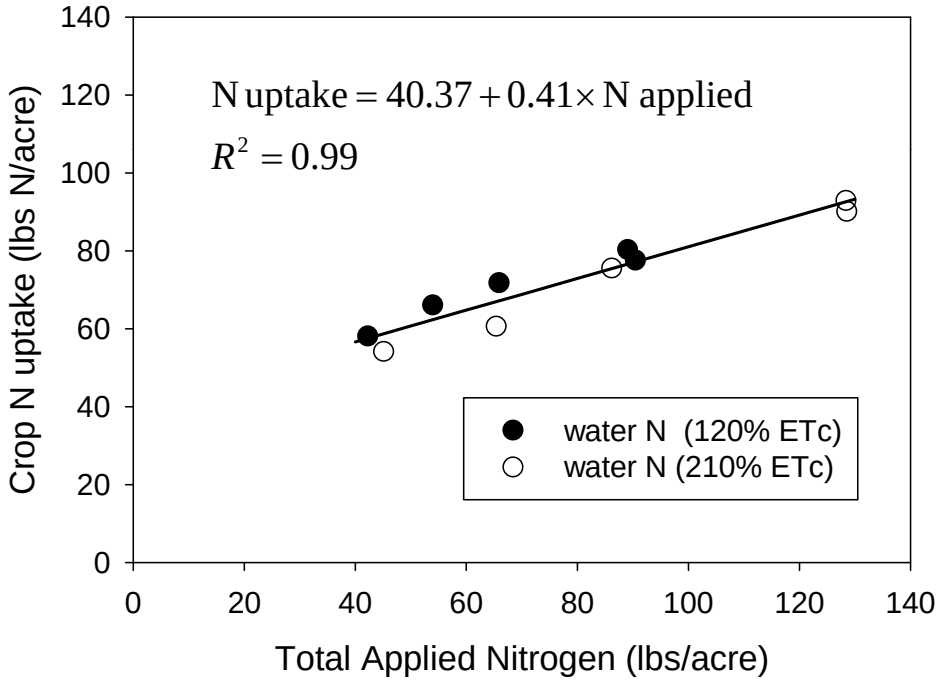


Crop Recovery of N from irrigation water:

Summer



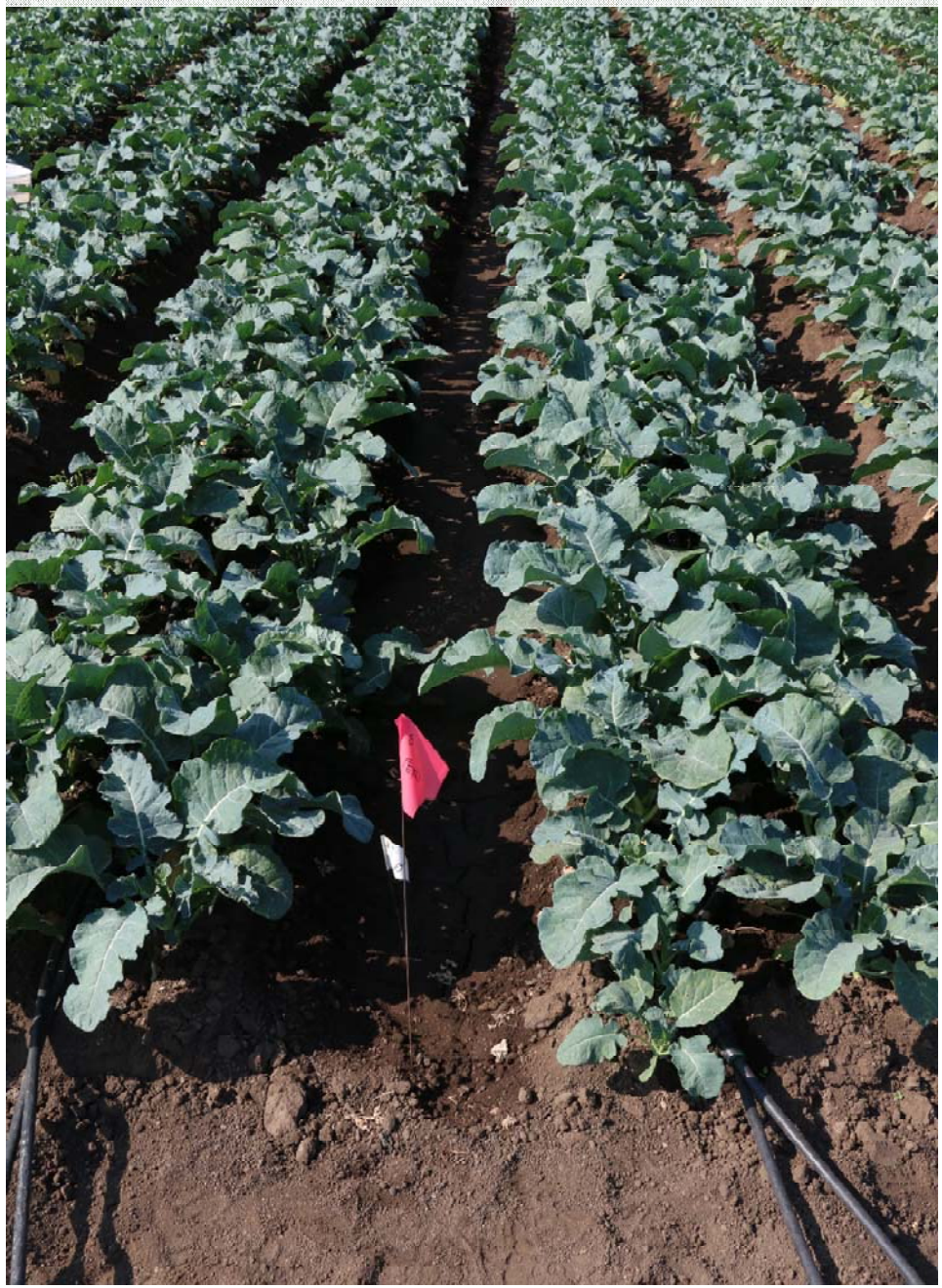
Fall

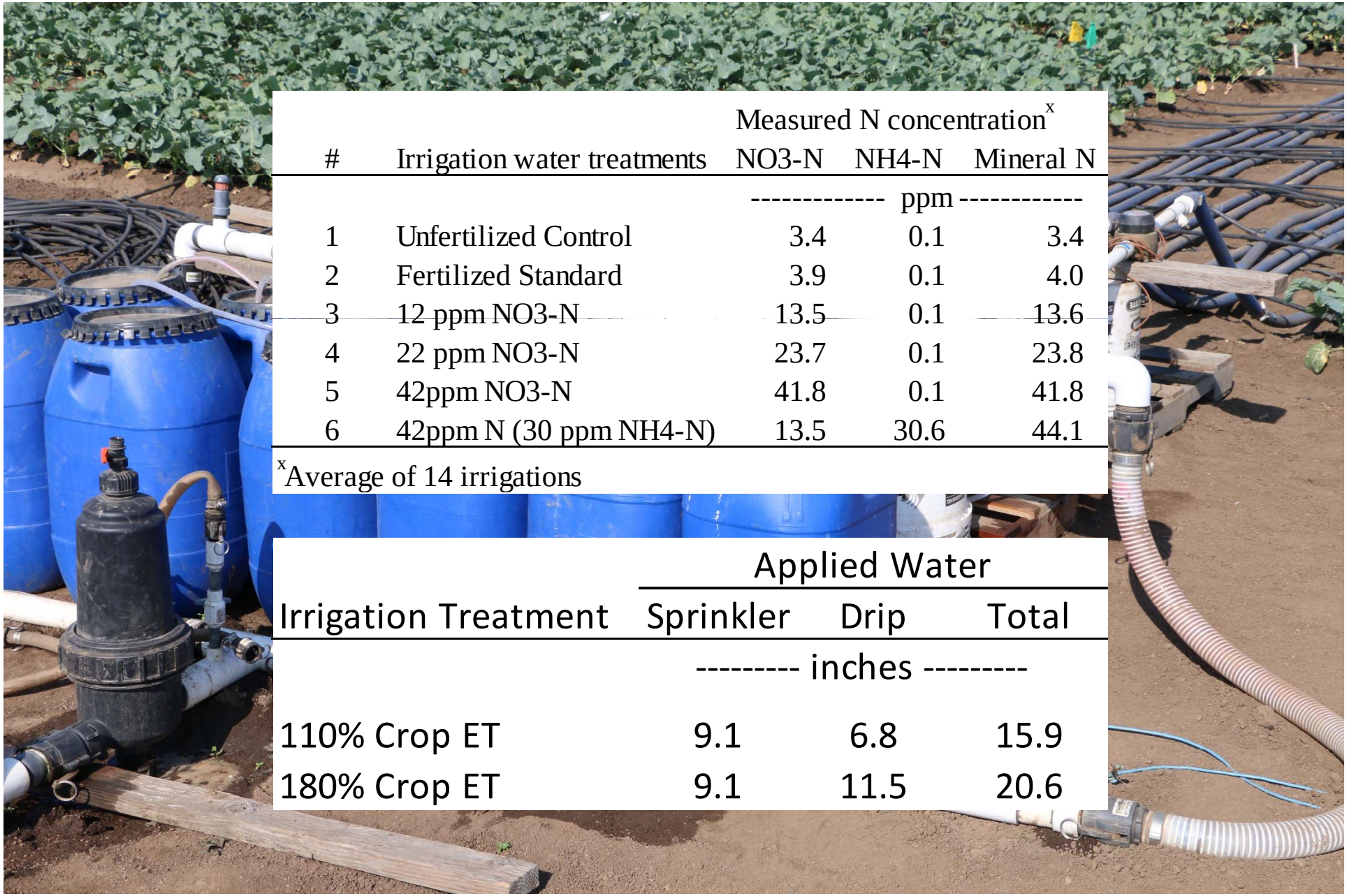


H_2O = 86% , Fertilizer std = 55%

H_2O = 41% , Fertilizer std = 20%

Broccoli: Deep rooted + high N demand (> 250 lbs N/acre)



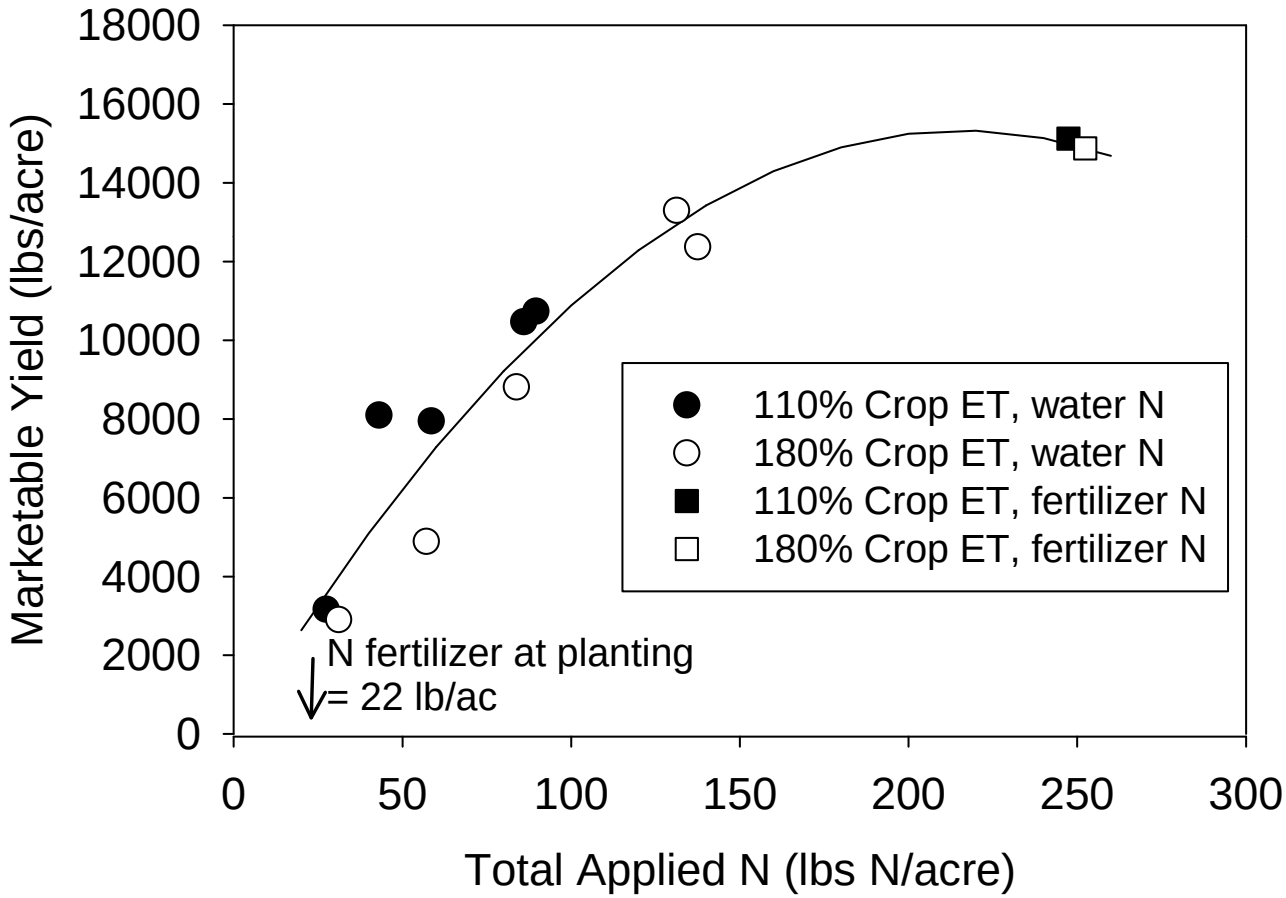


#	Irrigation water treatments	Measured N concentration[x] NO3-N	NH4-N	Mineral N
		---------- ppm ----------		
1	Unfertilized Control	3.4	0.1	3.4
2	Fertilized Standard	3.9	0.1	4.0
3	12 ppm NO3-N	13.5	0.1	13.6
4	22 ppm NO3-N	23.7	0.1	23.8
5	42ppm NO3-N	41.8	0.1	41.8
6	42ppm N (30 ppm NH4-N)	13.5	30.6	44.1

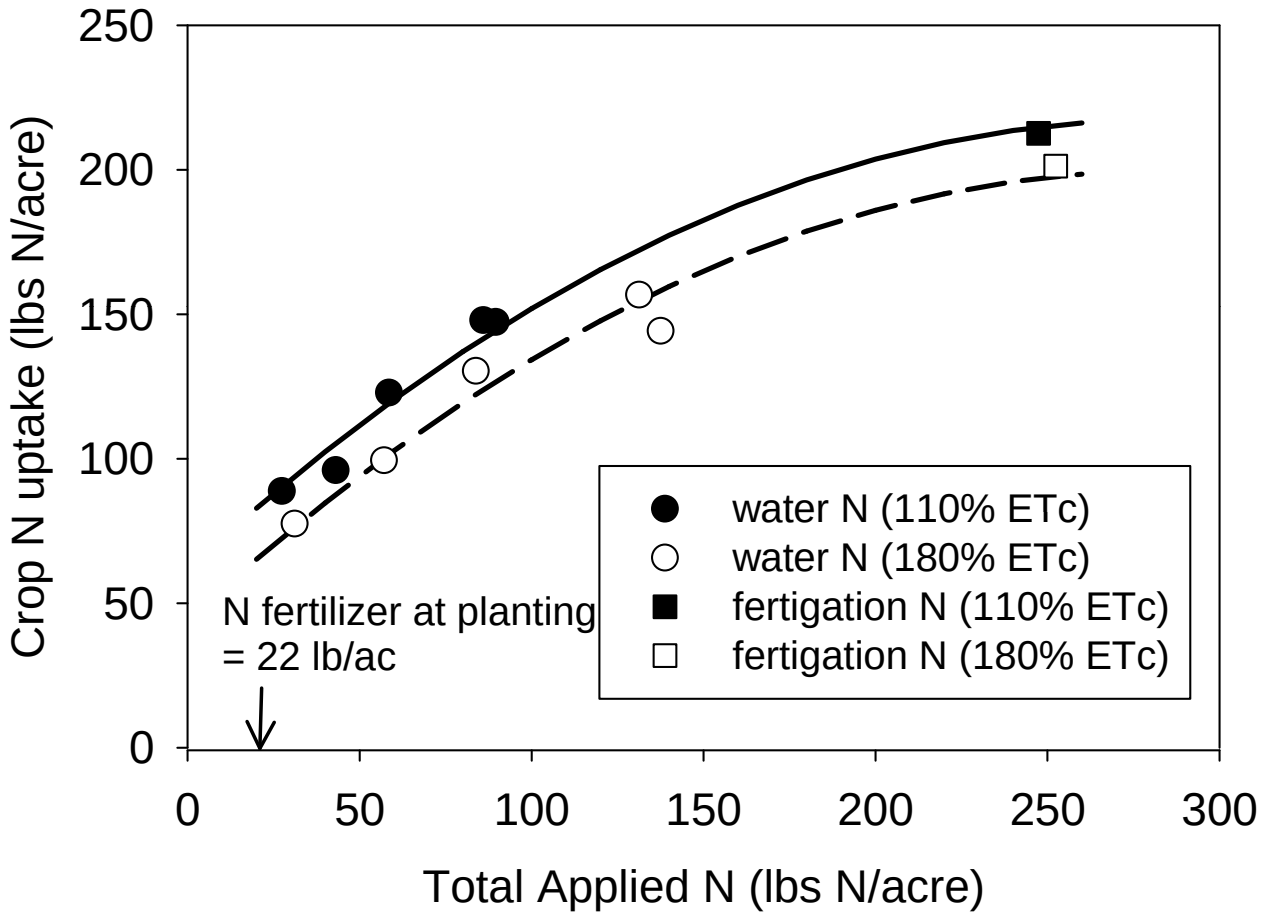
[x]Average of 14 irrigations

Irrigation Treatment	Applied Water Sprinkler	Drip	Total
	--------- inches ---------		
110% Crop ET	9.1	6.8	15.9
180% Crop ET	9.1	11.5	20.6

Irrigation Water Treatments Affected Marketable Yield



Irrigation Water Treatments Affected Crop Uptake of Nitrogen in Broccoli



H_2O = 100% , Fertilizer std = 55%

Integrating ambient N in water with soil nitrate testing

Soil Nitrate

+

N in water

Current N status of Soil

Future N contribution

Estimating Fertilizer N needs using the soil nitrate quick test

Recommended
Fertilizer N = Future Crop N uptake

– (Quick Test N - threshold NO_3-N)

– Plant residue N

– Soil Mineralization N

– Irrigation water N

Commercial Trial in Iceberg Lettuce

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N fertilizer treatments:

1. Grower Standard N Fertilizer Practice
2. N recommendation based on soil nitrate quick test
3. N recommendation based on SNQT + N in water

- Clay loam soil
- Planted 4/11/14 and harvested 6/16/14
- N in irrigation water: 5 ppm as NO_3-N, 31.6 ppm as NH_4-N

Commercial Iceberg

Recycled water (N = 37 ppm)

				Nitrogen Fertilizer Treatment		
Date	Crop Stage	Soil NO_3-N	Fertilizer	Standard	Quick NO_3 test	Quick NO_3 test + water NO_3
		ppm		---------- lbs N/acre ----------		
5/23/2014	1st drip fertigation	31.3	CAN-17	43	0	0
6/2/2014	2nd drip fertigation	20.0	CAN-17	11	32	27
Total				54	32	27

Commercial Iceberg Yields

Treatement	Carton Yield				Marketable Yield			
	Jumbo	24-size	30-size	Total	Jumbo	24-size	30-size	Total
	---------- cartons/acre----------				---------- lbs/acre----------			
Standard	169	951	6	1126	3439	15836	89	19364
Quick Nitrate Test	163	992	1	1156	3399	17341	13	20753
Quick Nitrate Test + Water	276	836	3	1115	5540	15075	40	20655
$LSD_{0.05}$	NS	NS	NS	NS	NS	NS	NS	NS

NS means are not statistically different at $p < 0.05$ level

Estimating N concentration when irrigating from multiple wells:

Determine average nitrate concentration in irrigation water

Various approaches for estimating N in irrigation water

1. $$\boldsymbol{lbs\ N/acre} = applied\ water\ (inches/acre) \times ppm\ N\ of\ water \times 0.23$$

2. $$\frac{\boldsymbol{lbs\ N/acre}}{\boldsymbol{hr}} = field\ application\ rate\ \left(\frac{in}{hr}\right) \times ppm\ N\ of\ water \times 0.23$$

3. $$\boldsymbol{lbs\ N} = \frac{gallons \times ppm\ N\ of\ water}{118061}$$

4. $$\boldsymbol{lbsN/hr} = \frac{gpm\ of\ well \times ppm\ N\ of\ water}{1968}$$

Estimating N applied in irrigation water from flow rate

$$lbsN/hr = \frac{gpm\ of\ well \times ppm\ N of\ water}{1968}$$

	---------- N concentration in well water (ppm) ----------							
Well flow rate	5	10	15	20	25	30	35	40
gpm	---------- lbs N per hour ----------							
200	0.5	1.0	1.5	2.0	2.5	3.0	3.6	4.1
400	1.0	2.0	3.0	4.1	5.1	6.1	7.1	8.1
600	1.5	3.0	4.6	6.1	7.6	9.1	10.7	12.2
800	2.0	4.1	6.1	8.1	10.2	12.2	14.2	16.3
1000	2.5	5.1	7.6	10.2	12.7	15.2	17.8	20.3
1200	3.0	6.1	9.1	12.2	15.2	18.3	21.3	24.4
1400	3.6	7.1	10.7	14.2	17.8	21.3	24.9	28.5
1600	4.1	8.1	12.2	16.3	20.3	24.4	28.5	32.5
1800	4.6	9.1	13.7	18.3	22.9	27.4	32.0	36.6
2000	5.1	10.2	15.2	20.3	25.4	30.5	35.6	40.7

Estimating applied N in irrigation water

Example :

Well flow rate = 1000 gpm
Nitrate-N concentration = 20 ppm
Irrigation time = 5 hours
Irrigated area = 10 acres

Step 1: calculate lbs of N applied per hour

$$\frac{lbsN}{hr} = \frac{1000\ gpm \times 20\ ppm}{1968} = 10.2\ lbs/hr$$

Step 2: calculate lbs of N applied per acre

$$\frac{lbsN}{acre} = \frac{10.2\ \frac{lbs}{hr} \times 5\ hrs}{10\ acres} = 5.1\ lbs/acre$$

Summary

- ✓ N in irrigation water has the same nutrient value for lettuce and broccoli as fertilizer sources of N
- ✓ Low concentrations of nitrate-N (12 ppm) in irrigation water were taken up by lettuce and broccoli
- ✓ Fertilizer value of NH_4 and NO_3 sources of N were equivalent
- ✓ Volume of water applied to the crop did not affect the recovery rate of N from the irrigation water